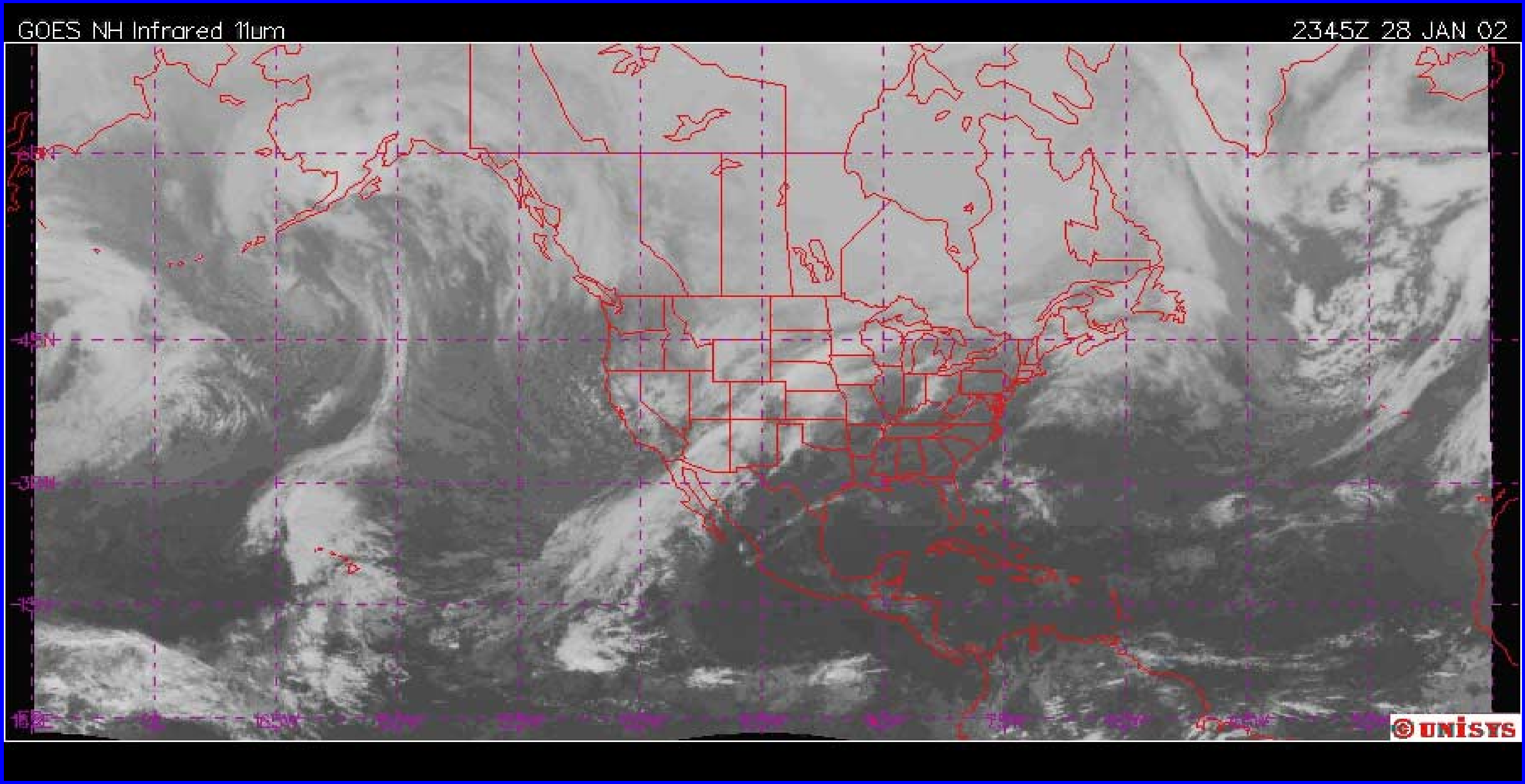
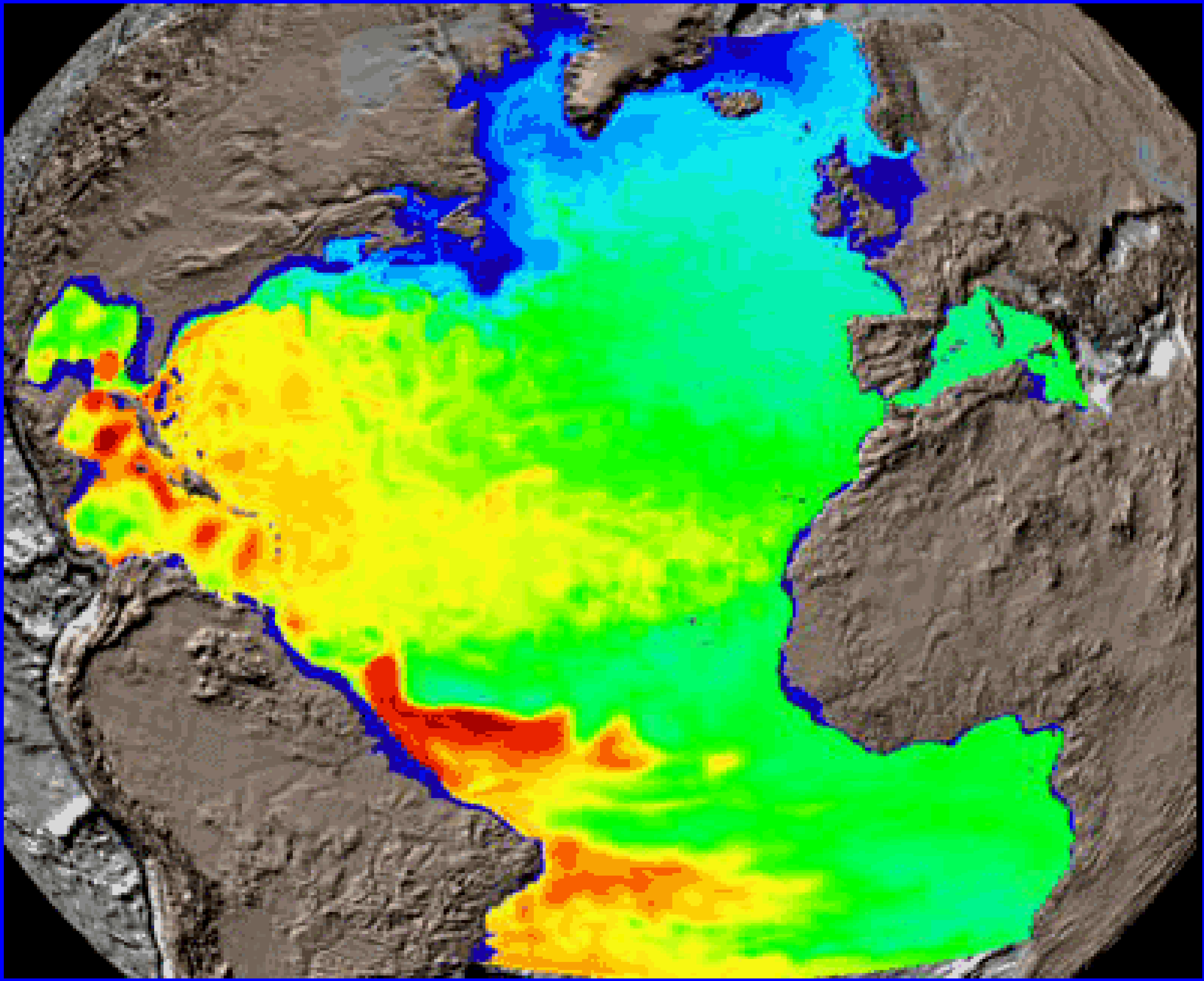
A Satellite View of Atmospheric Weather



GOES Infrared Imagery – January 2002

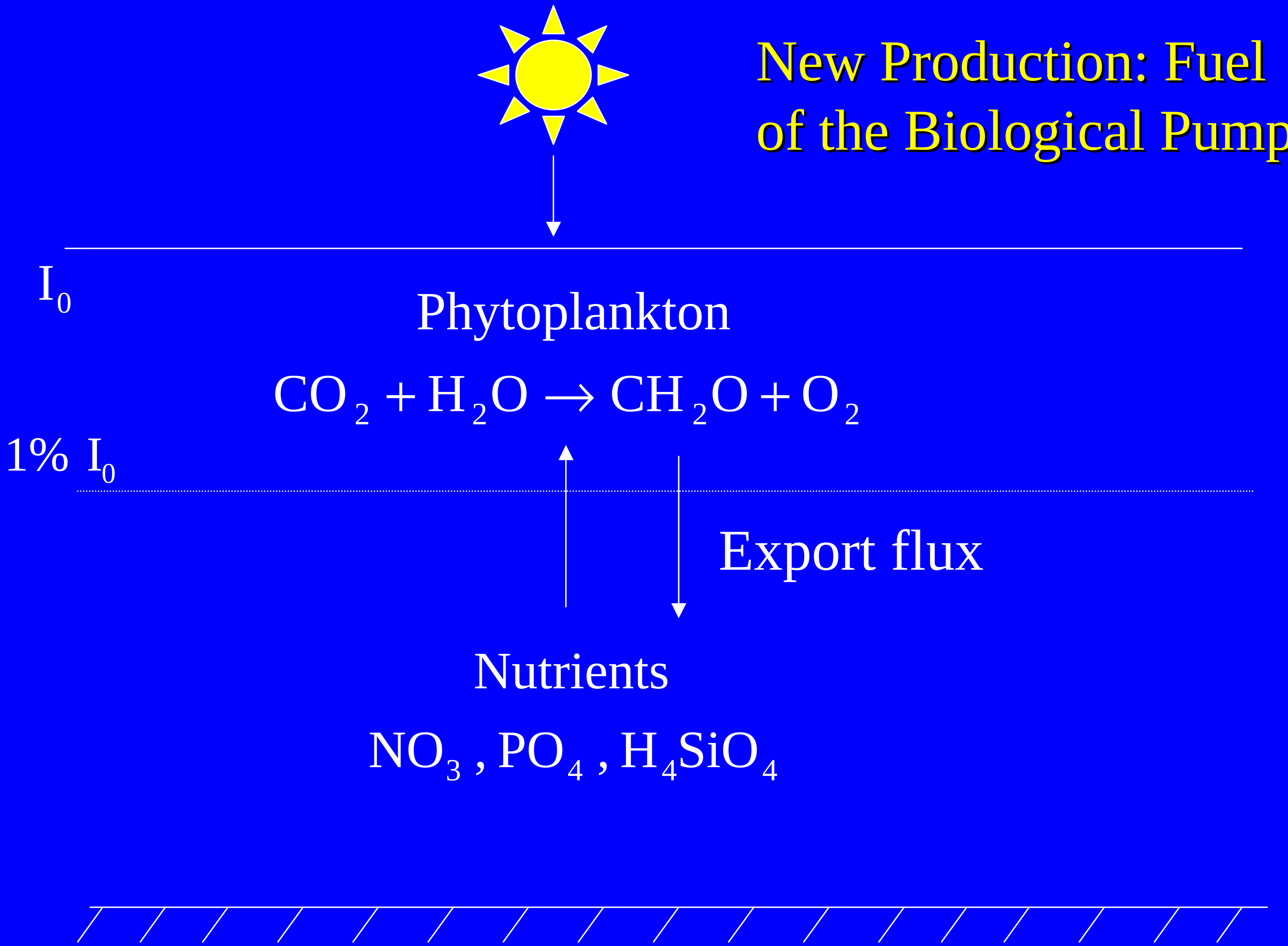
A Computer Simulation of the Ocean's Internal Weather



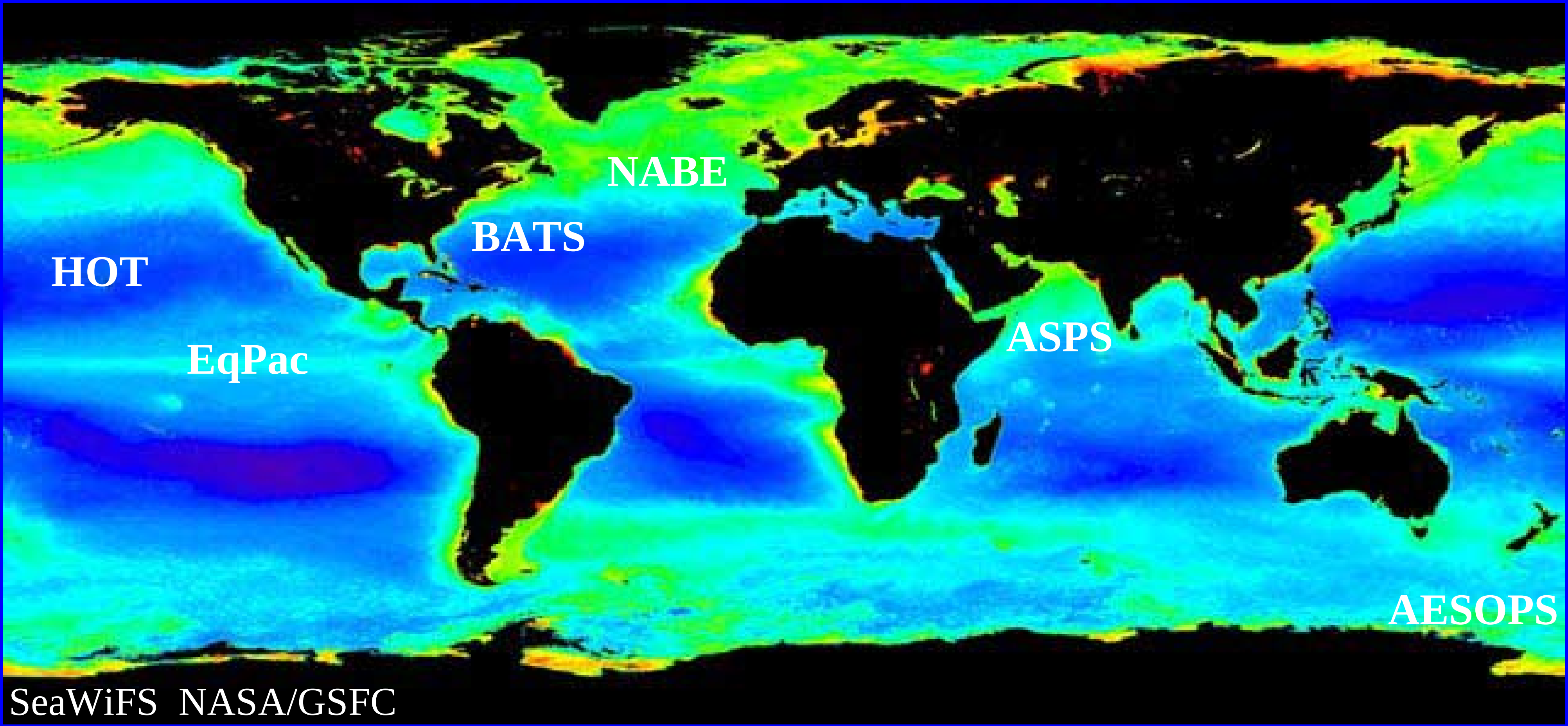
Temperature at 100m

Simulation duration: 1 year

Simulation courtesy of
Mat Maltrud, Los Alamos National Laboratory

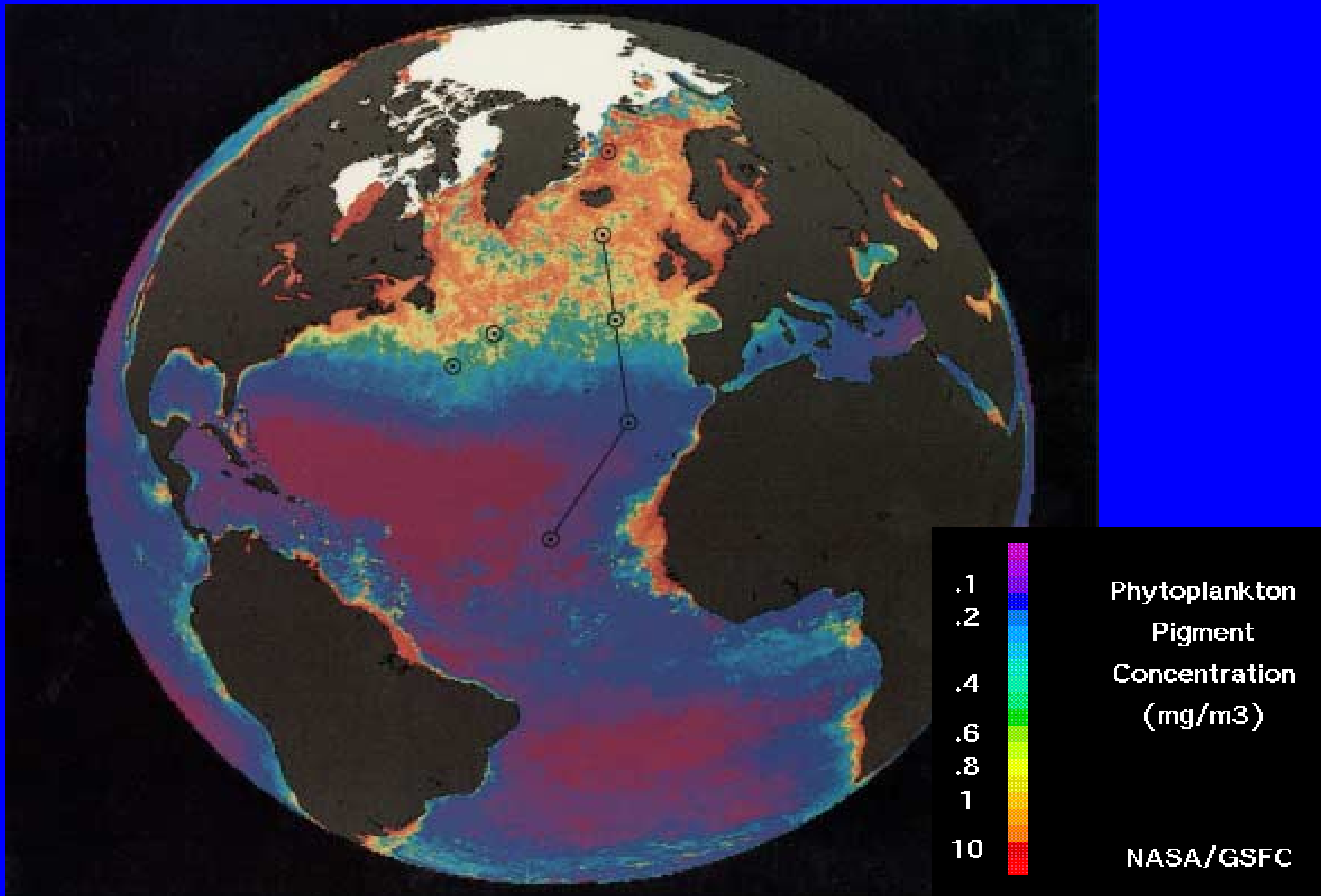

New Production: Fuel of the Biological Pump
I_0
Phytoplankton
$CO_2 + H_2O \rightarrow CH_2O + O_2$
1% I_0
Export flux
Nutrients
NO_3 , PO_4 , H_4SiO_4

The Internal Weather of the Sea and its Influences on Ocean Biogeochemistry

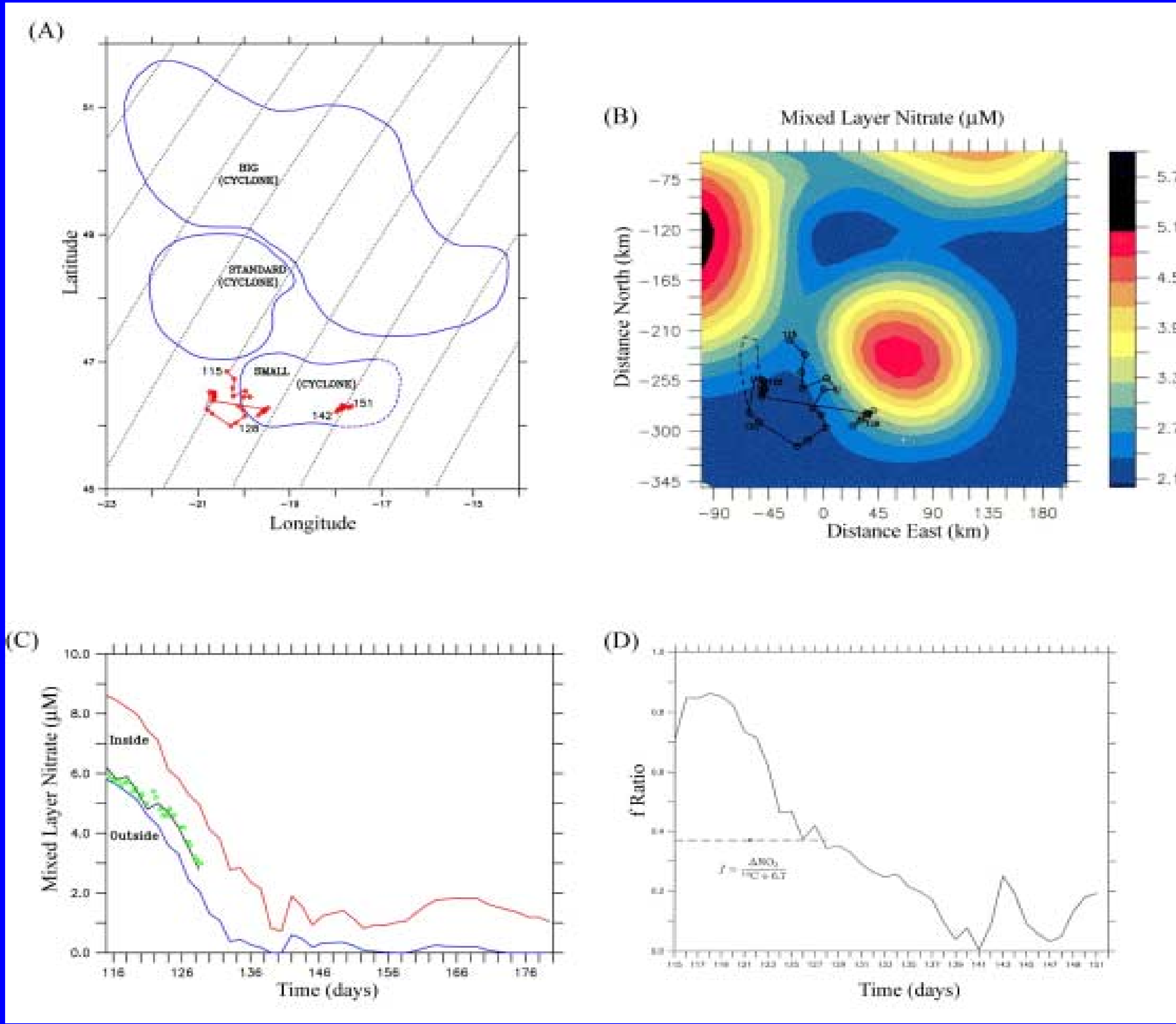


1. Variability in observations   2. Processes influence mean fluxes

North Atlantic Bloom Experiment



CZCS April-June Composite Image by Gene Feldman



(A)
BIG (CYCLONE)
STANDARD (CYCLONE)
SMALL (CYCLONE)
115
128
142
151
Latitude
Longitude
(B)
Mixed Layer Nitrate (μM)
Distance North (km)
Distance East (km)
(C)
Inside
Outside
Mixed Layer Nitrate (μM)
Time (days)
(D)
f Ratio
Time (days)

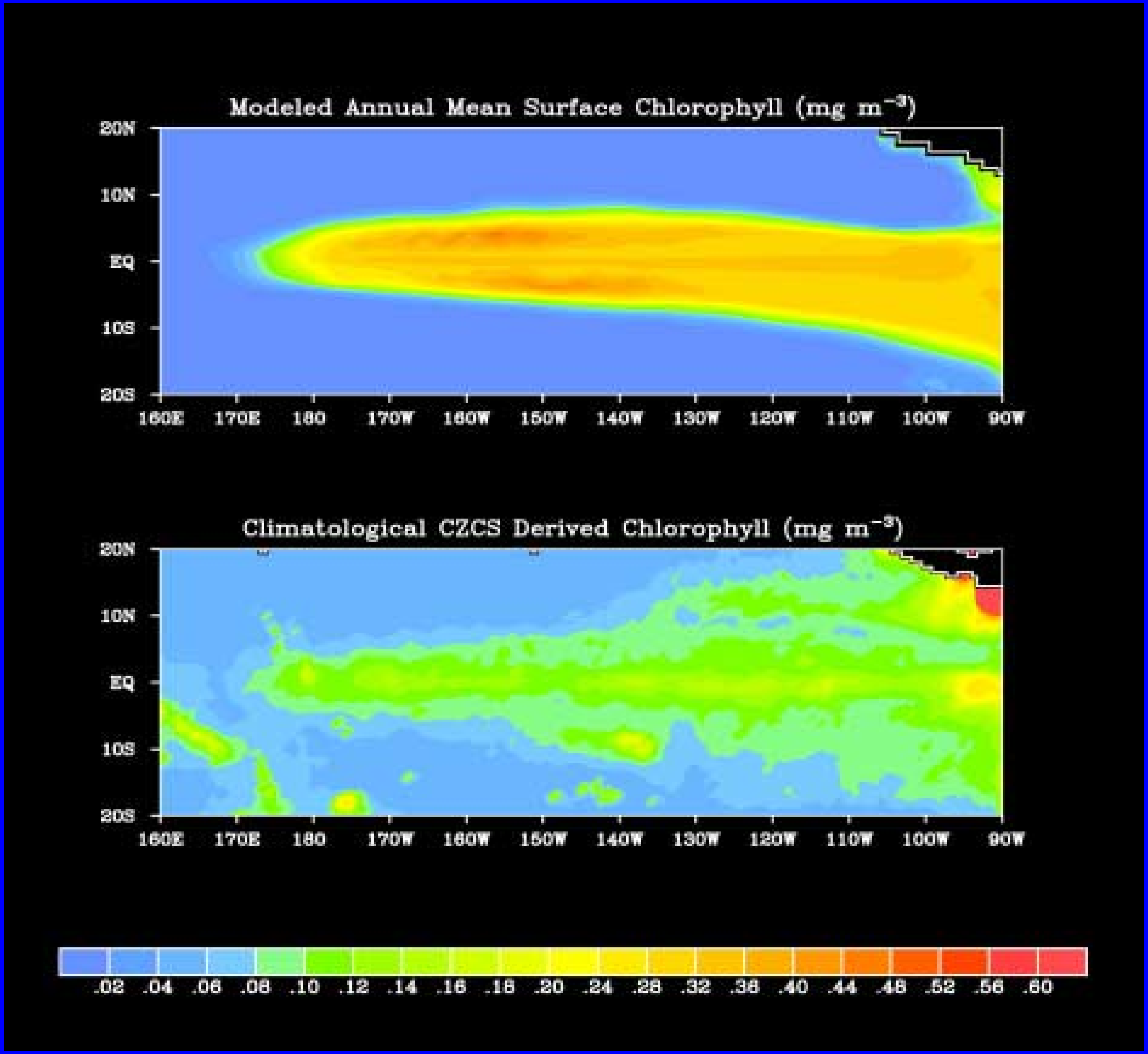
Impacts of eddies on the Spring Bloom in the North Atlantic

1. Heterogeneity in the “initial conditions”

2. Supply of nutrients for the post-bloom period

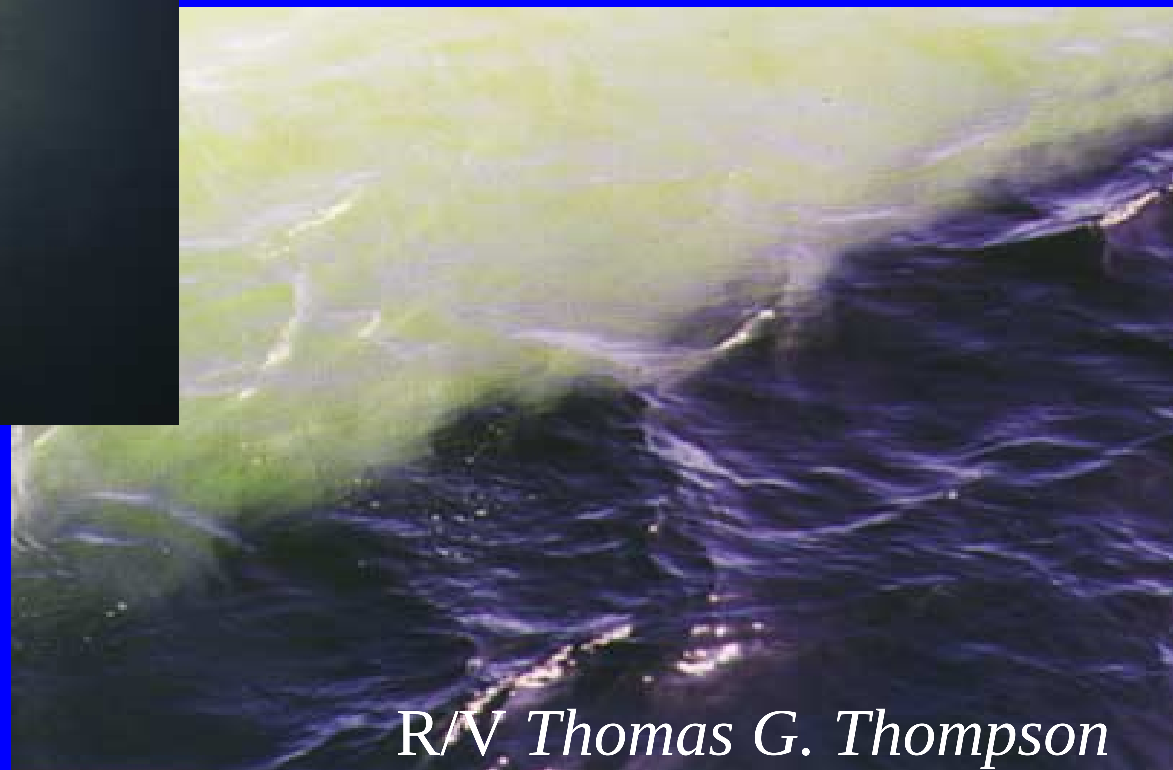
3. Mesoscale variability in particle flux to the deep sea (Newton et al. 1994)

Equatorial Pacific Process Study

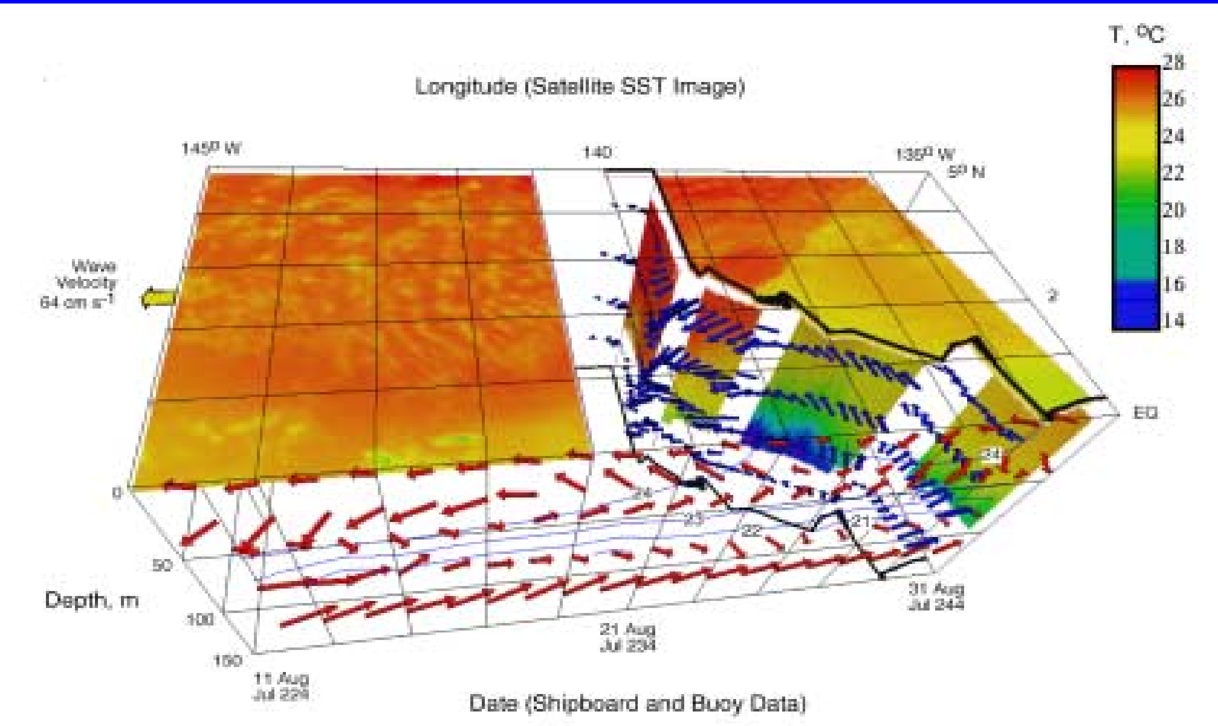


Chai et al. (1996)

A Line in the Sea – Yoder et al. (1994)

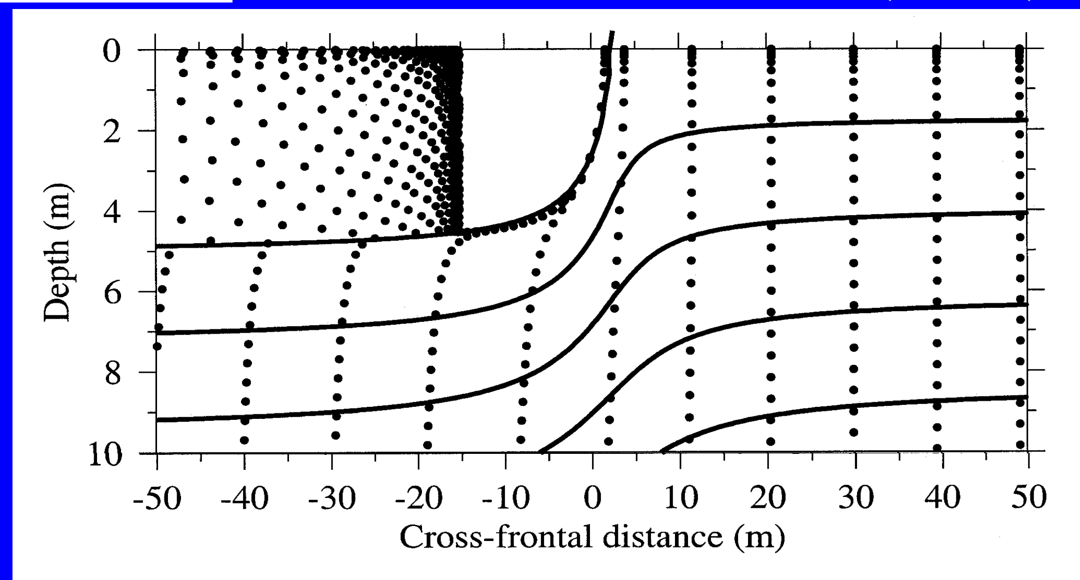


A Line in the Sea



Archer et al. (1997)

Franks (1997)



Spatial and temporal variability of phytoplankton pigment distributions in the central equatorial Pacific Ocean

ROBERT R. BIDIGARE* and MICHAEL E. ONDRUSEK*

"…the TIW resulted in a twofold increase in Chl… [and]…a fivefold increase in Chl biomass of diatoms…"

Export production of particles to the interior of the equatorial Pacific Ocean during the 1992 EqPac experiment

SUSUMU HONJO,* JACK DYMOND,† ROBERT COLLIER† and STEVEN J. MANGANINI*

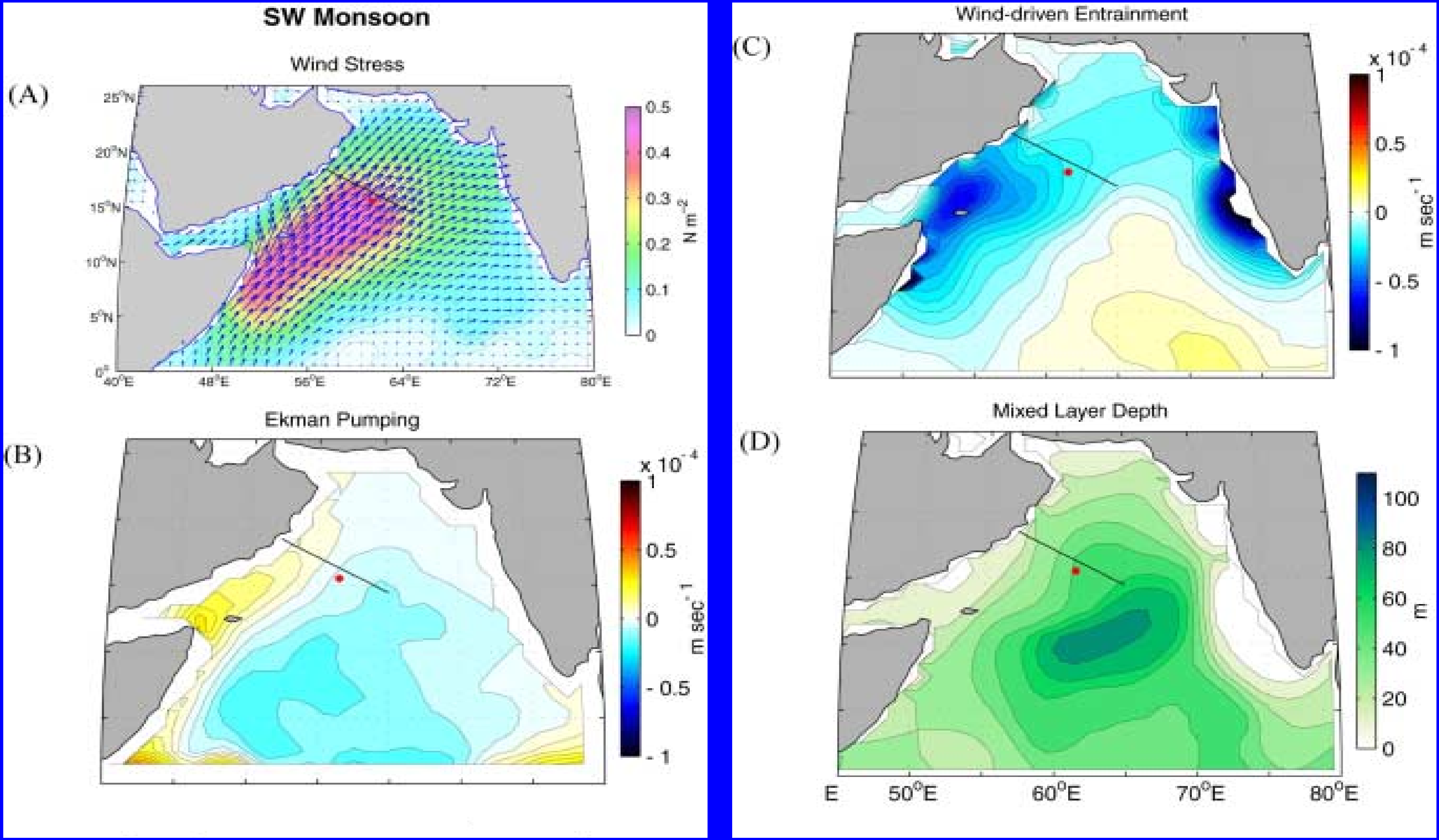
"Two large organic carbon and biogenic SiO_2 flux events… coincided with intense TIWs that passed through the region…"

Physical control of biological processes in the central equatorial Pacific Ocean

Marjorie A.M. Friedrichs*, Eileen E. Hofmann

"A 60-70% increase in Chl… and a 400% increase in Chl contribution of diatoms was associated with…a TIW"

Arabian Sea Process Study



Lee et al. (2000)

A coastal filament in the open ocean

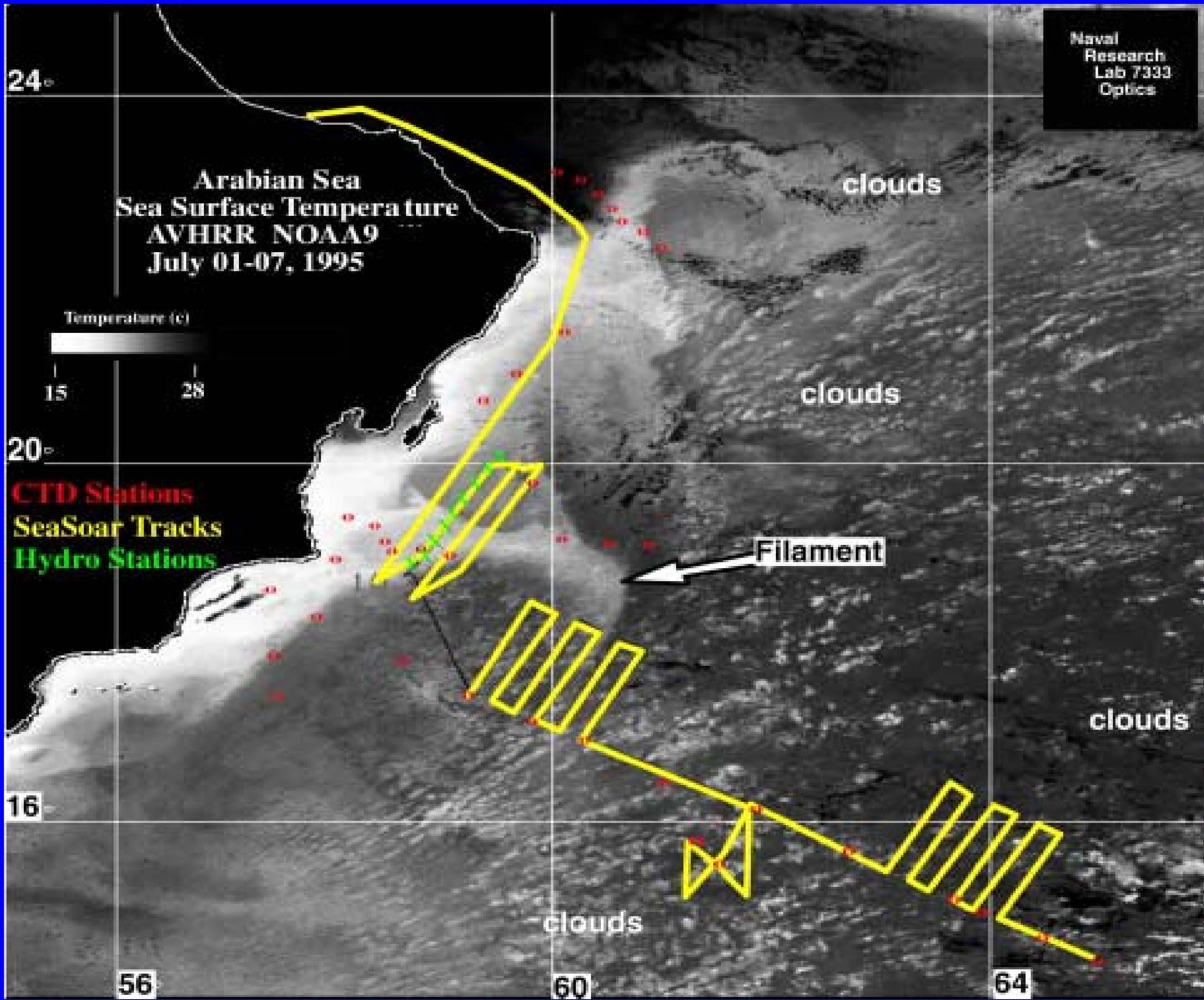


Image courtesy of Bob Arnone

Filament:

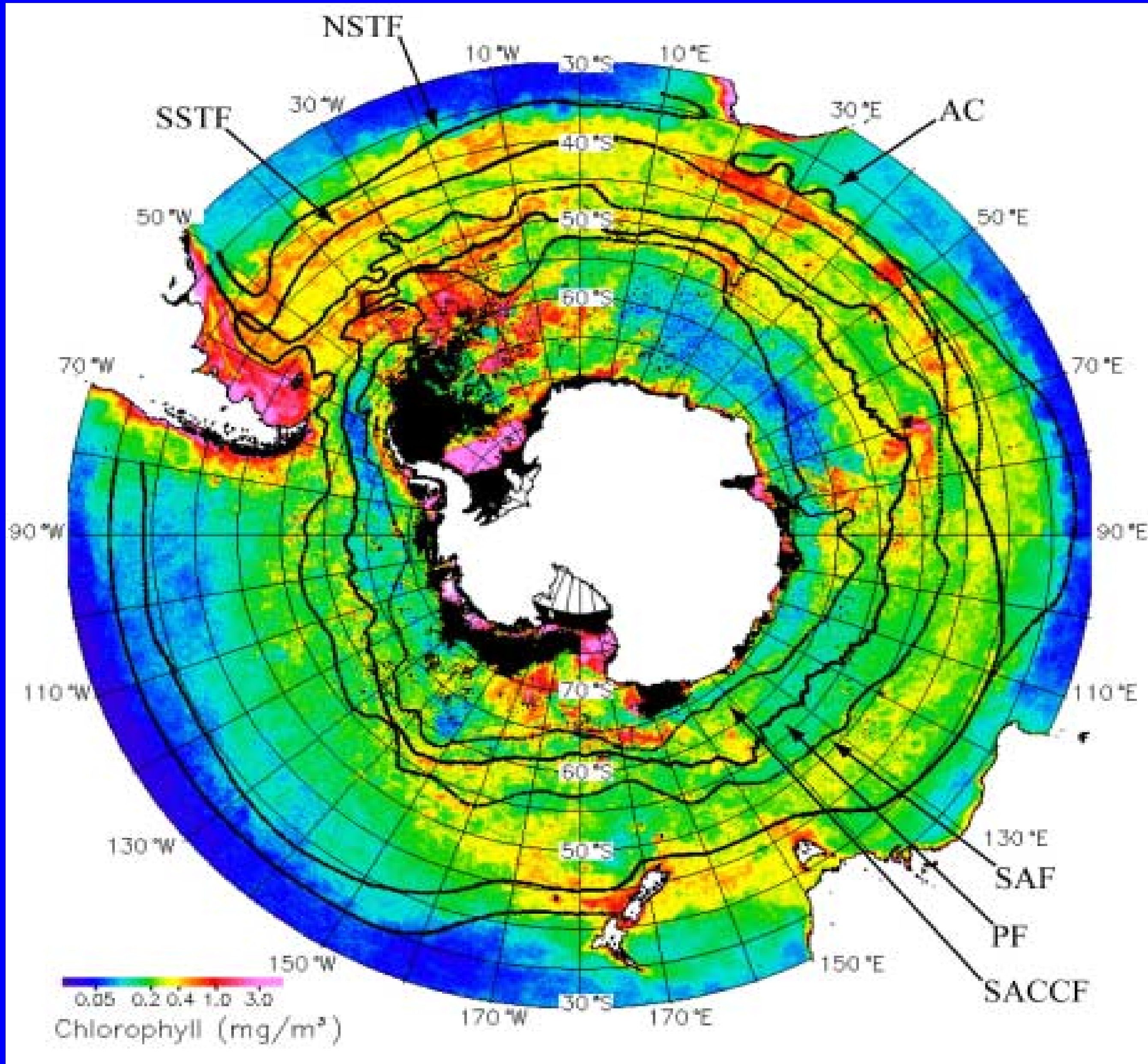
Highest biomass and productivity during SW monsoon (Barber et al. 2001)

High diatom biomass (Latasa and Bidigare, 1998)

Depletion of silicic acid (Morrison et al. 1998)

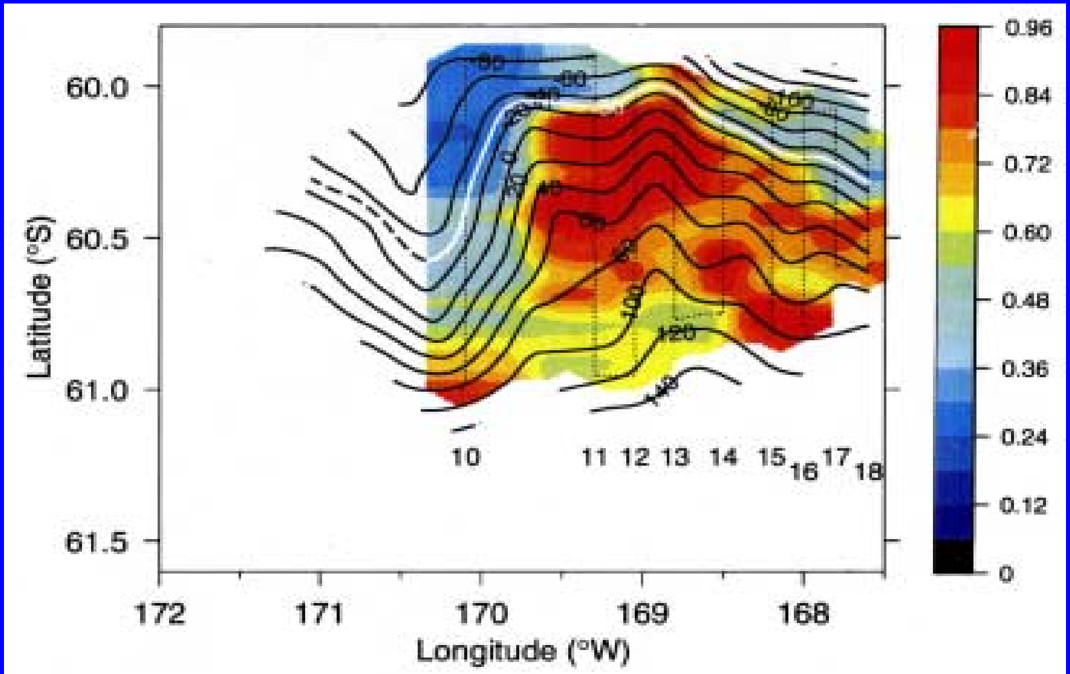
Shifts in species composition associated with large export events (Honjo et al. 1999)

Antarctic Environment Southern Ocean Process Study

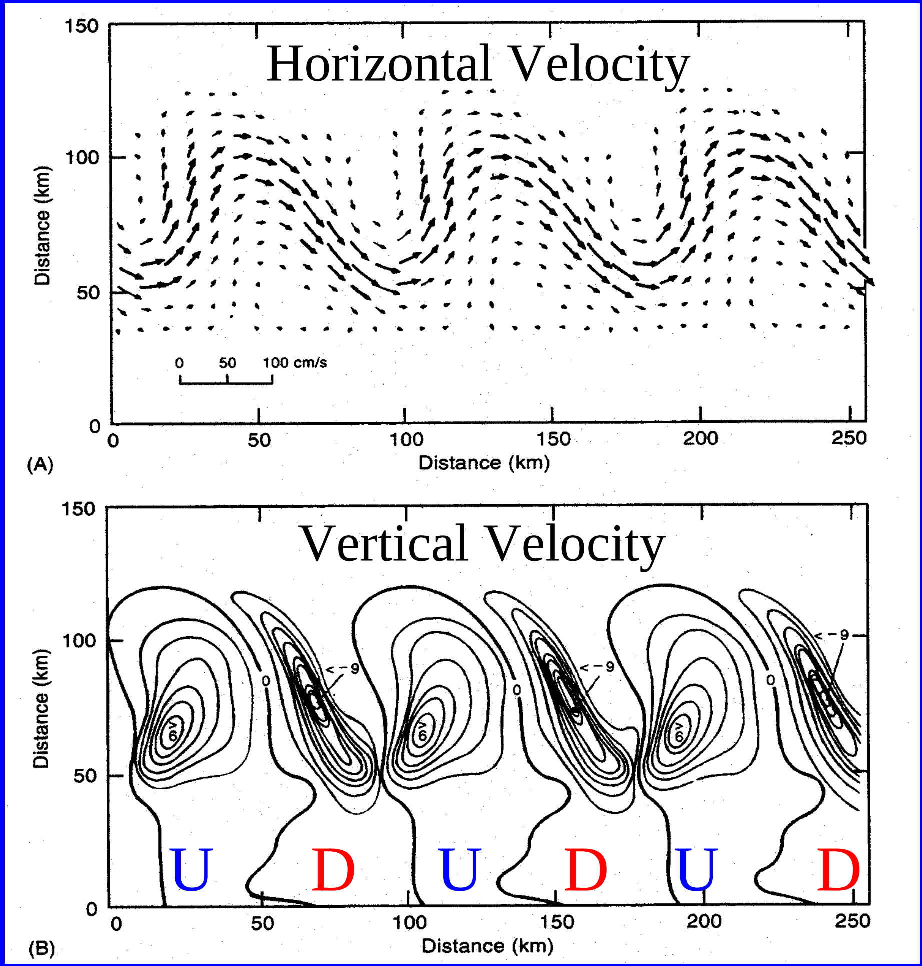


Moore & Abbott (2000)

SeaSoar Survey of chlorophyll in a meander of the Antarctic Polar Front

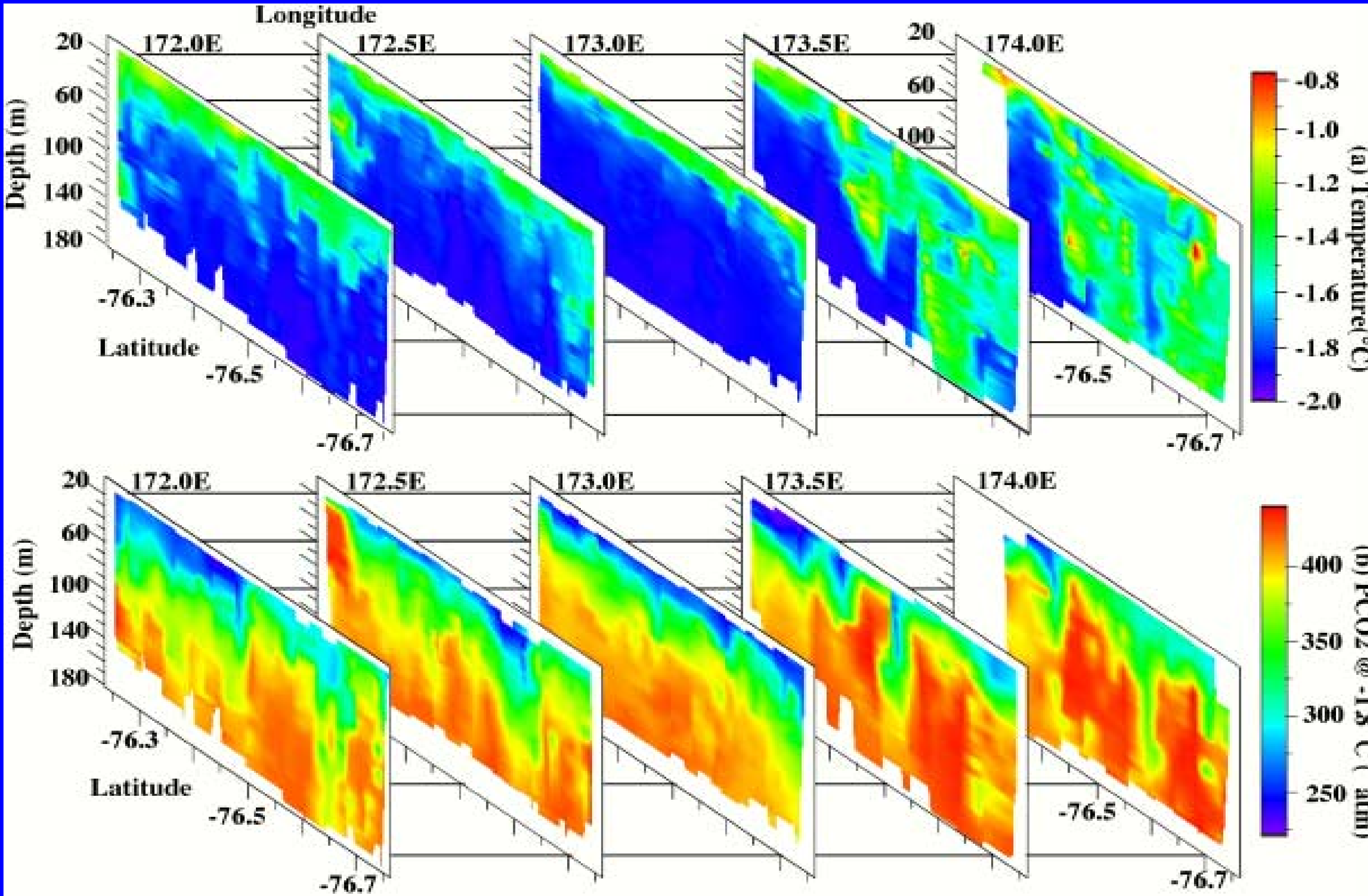


Barth et al. (2001)



Model simulation by Woods (1988) "Mesoscale upwelling and primary production"

Small scale variability in the Ross Sea

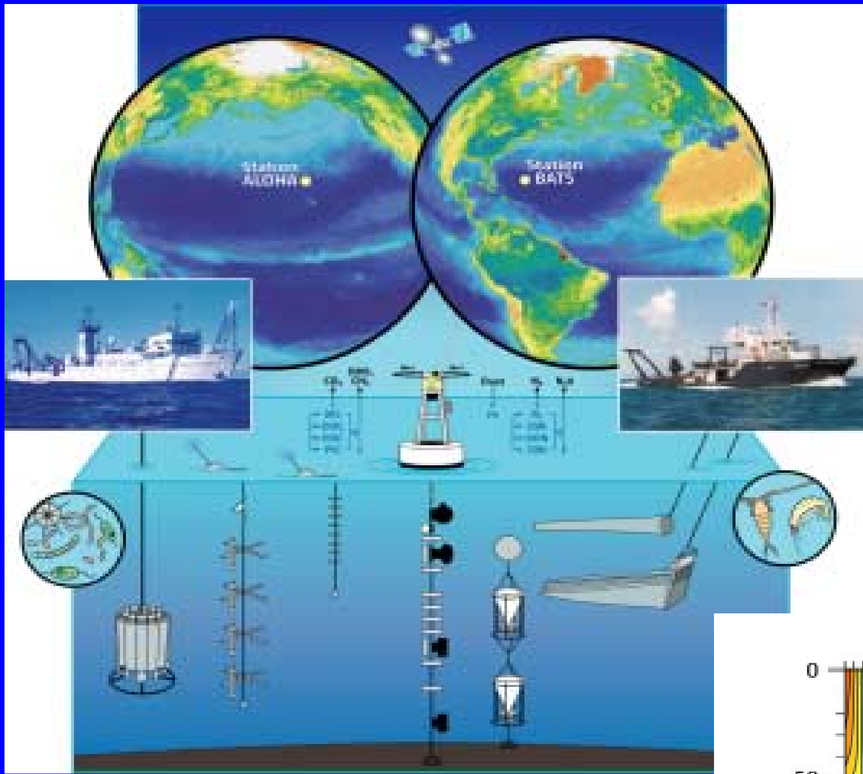


Temp.

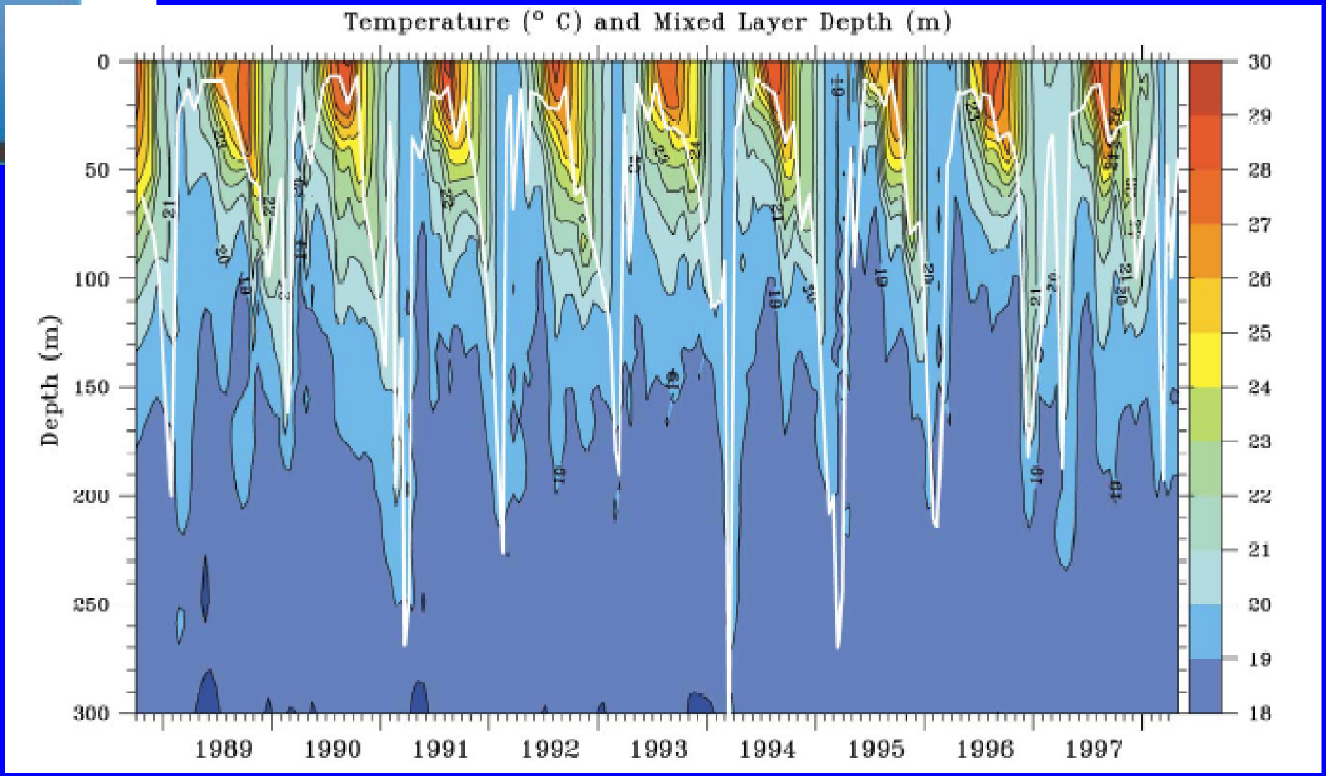
pCO_2

Hales, B., Sweeney, C. and T. Takahashi: "…resolution as fine as 15km misses 2/3 of the total variability in well-resolved fields…"

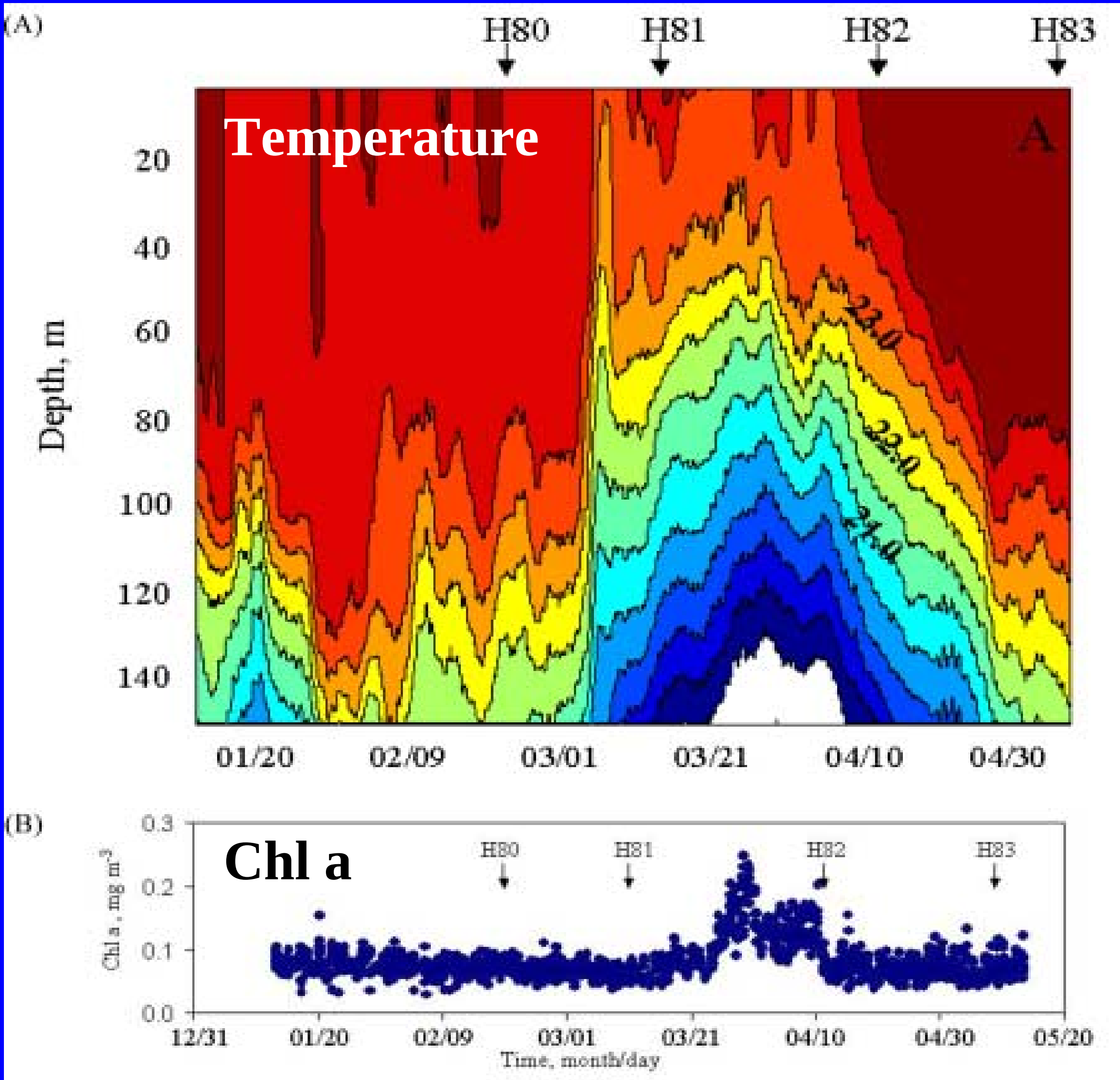
Time-series at HOT and BATS



Steinberg et al. (2001)



An eddy event at HALE ALOHA in spring of 1997



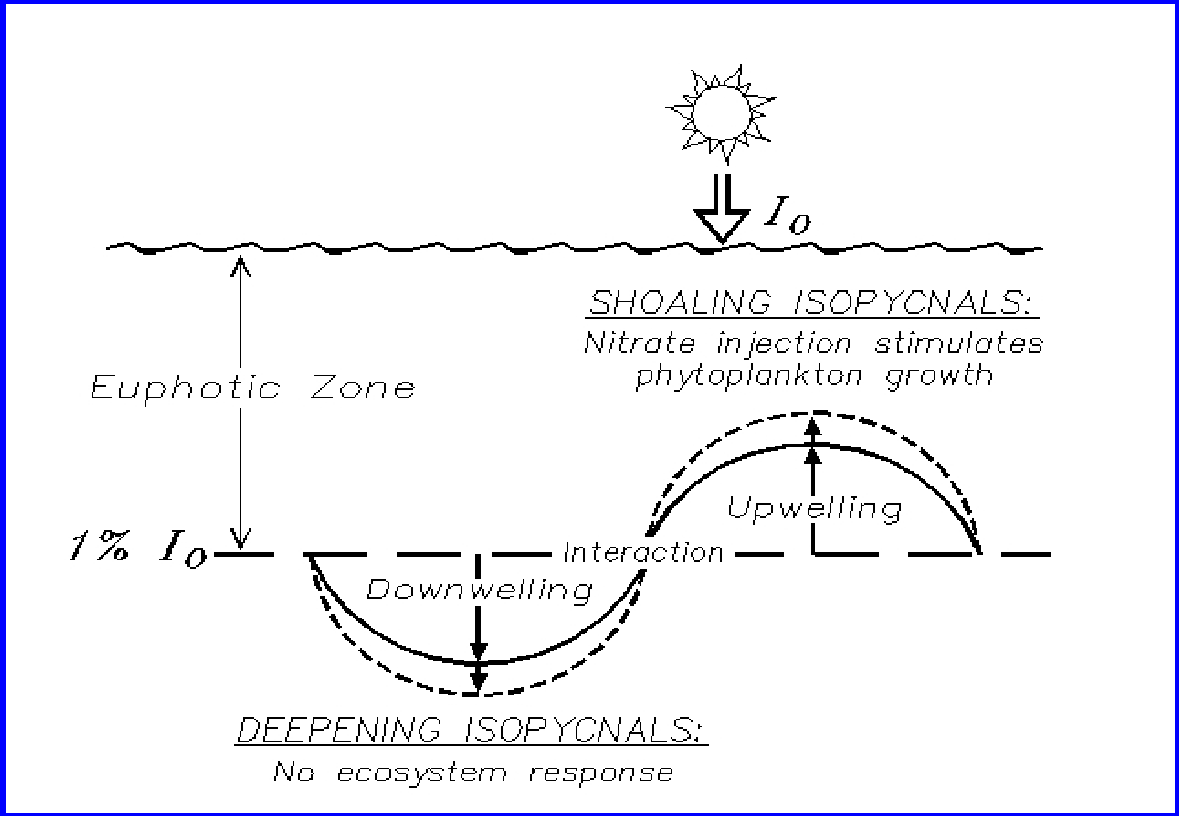
Letelier et al. (2000)

Threefold increase in 0-25m Chl

Increase in 0-100m $NO_3 + NO_2$ of *four orders of magnitude*

Twofold increase in diatom component of total Chl.

Influence of Mesoscale Eddies on New Production in the Sargasso Sea



Observations:

Moored time series (McNeil et al., 1999)

Mesoscale surveys (McG. et al., 1999)

Ocean color / SST imagery (McG. et al., 2001)

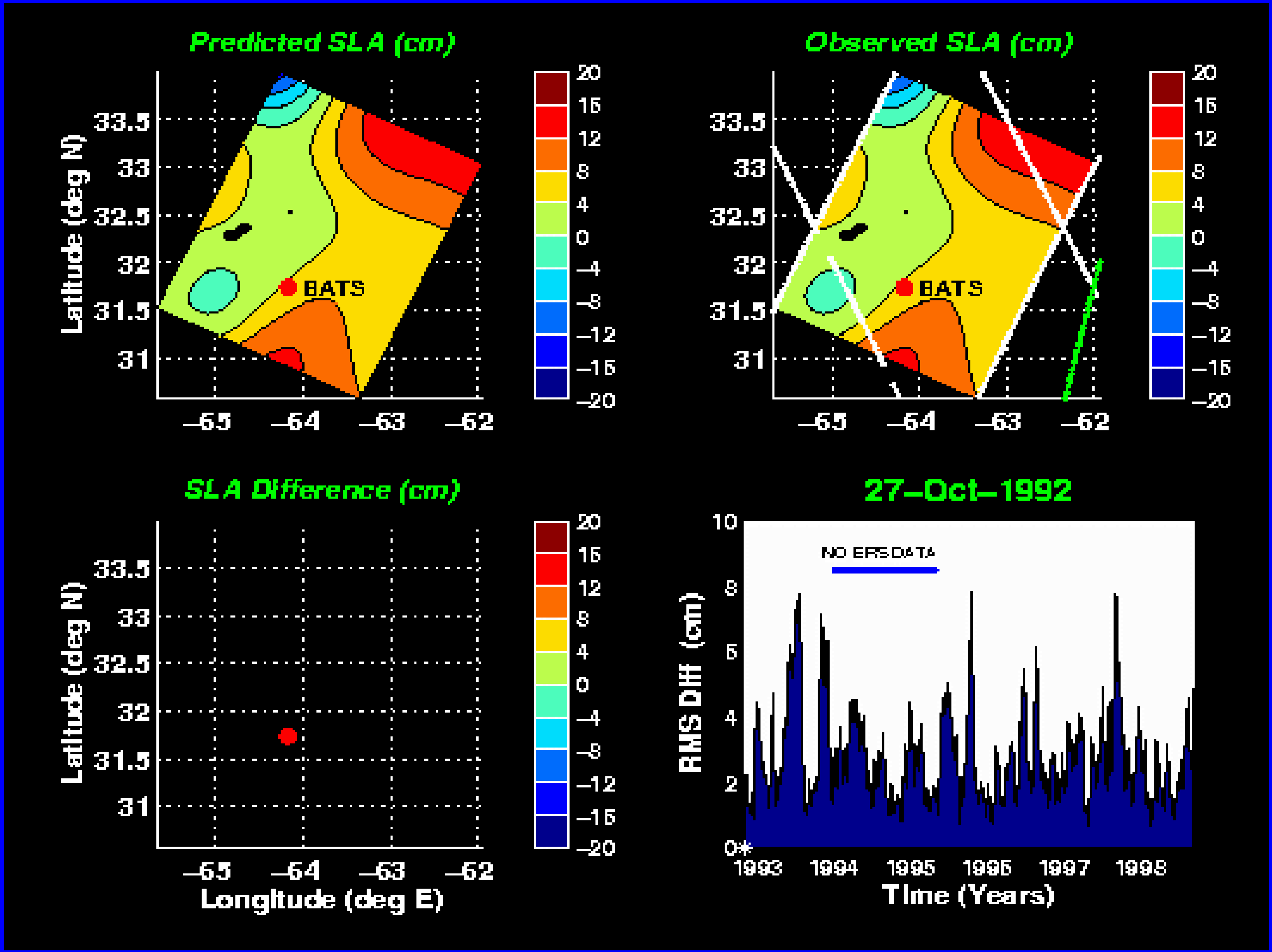
Flux estimates:

Regional simulations (McG. et al., 1998)

Satellite-based kinematics (Siegel et al., 1999)

Basin-scale simulations (McG. et al., 2003)

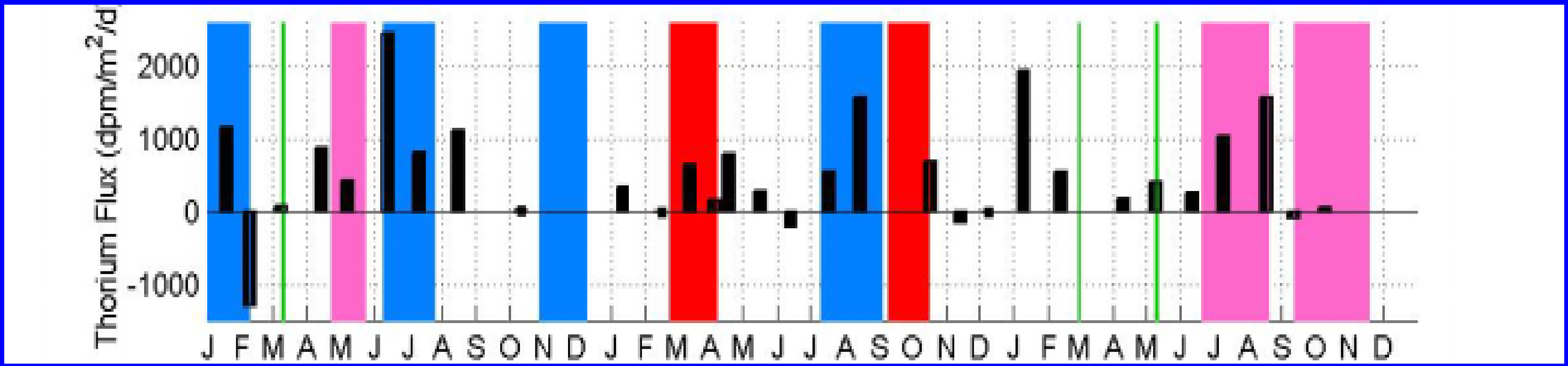
A Regional Hindcast Model Around BATS



Valery Kosnyrev http://science.whoi.edu/users/mcgillic/tpd/tpd.html

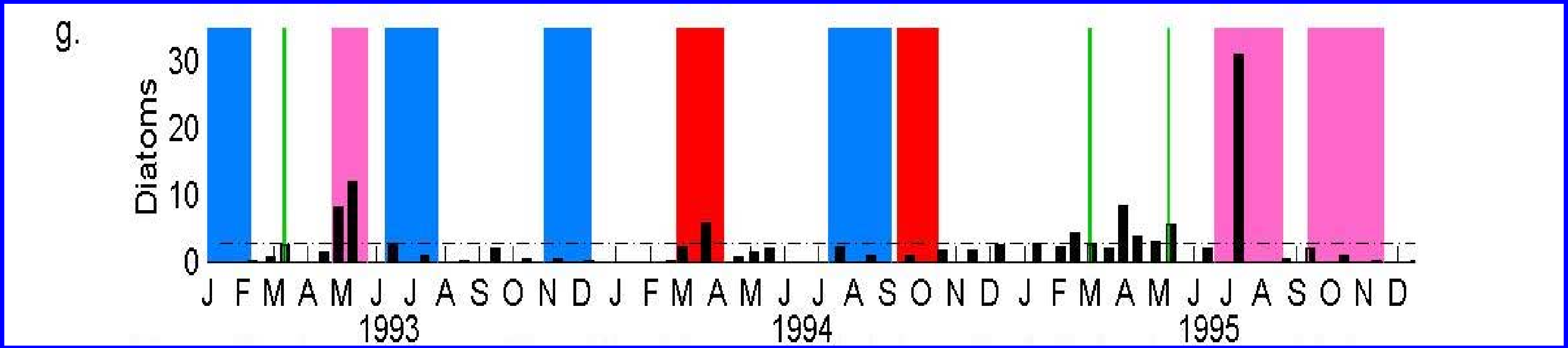
Eddy Impacts on Phytoplankton Species Composition and Export

Sweeney et al. (in press)



Buesseler Th Flux Data

% total Chl



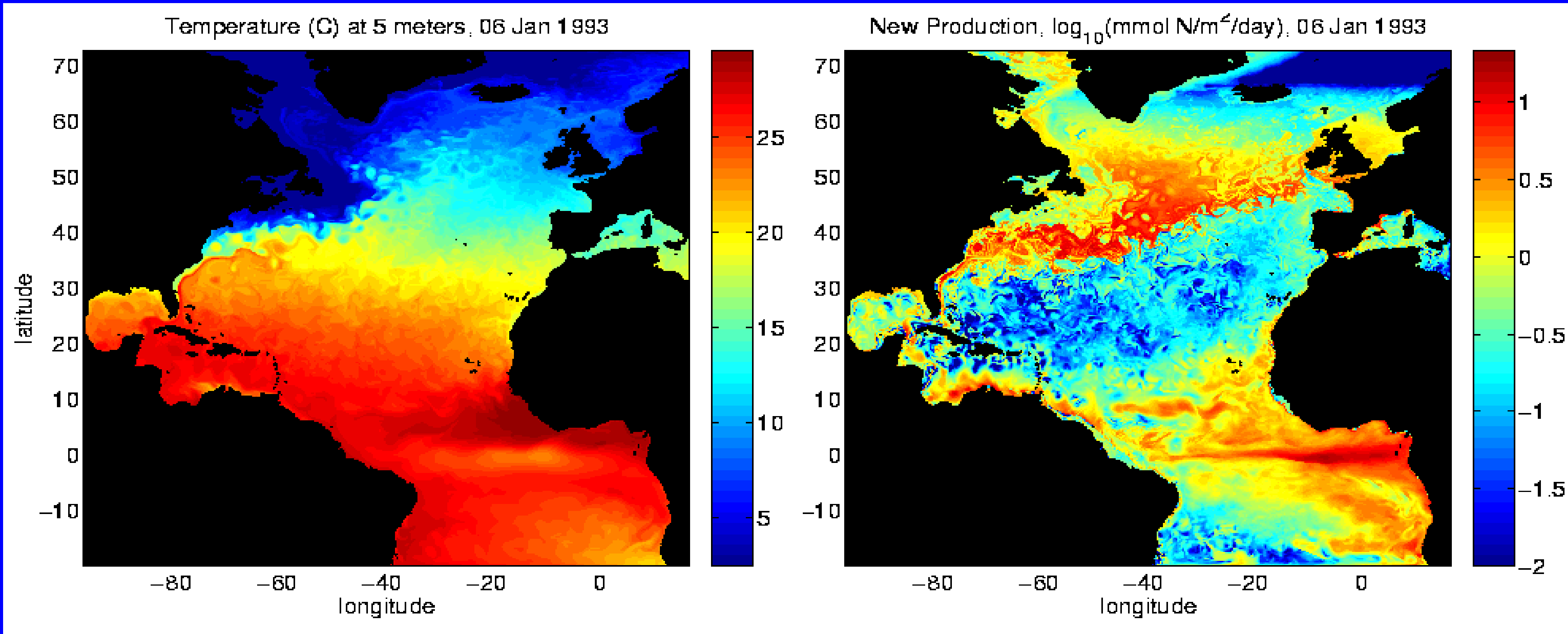
BATS HPLC + Letelier et al. (1993)

Blue: Cyclones Red: Anticyclones Pink: Mode-water Eddies

An eddy-resolving model of the North Atlantic

Temperature

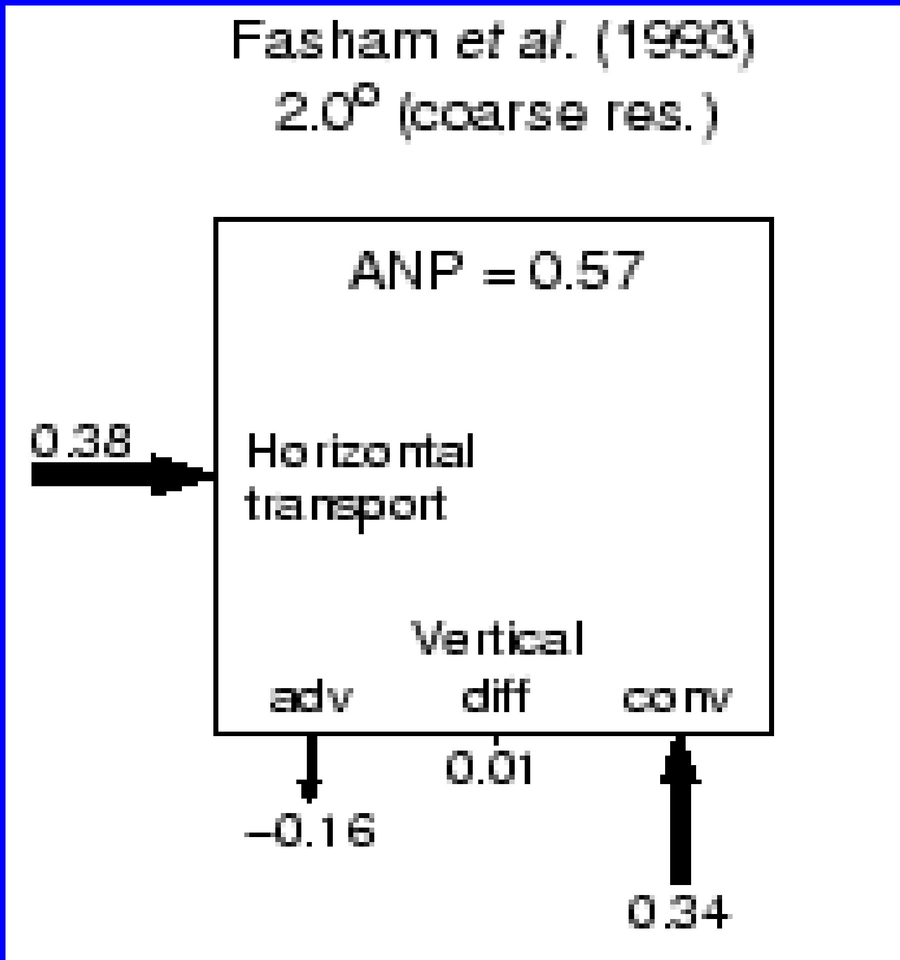
log (New Production)



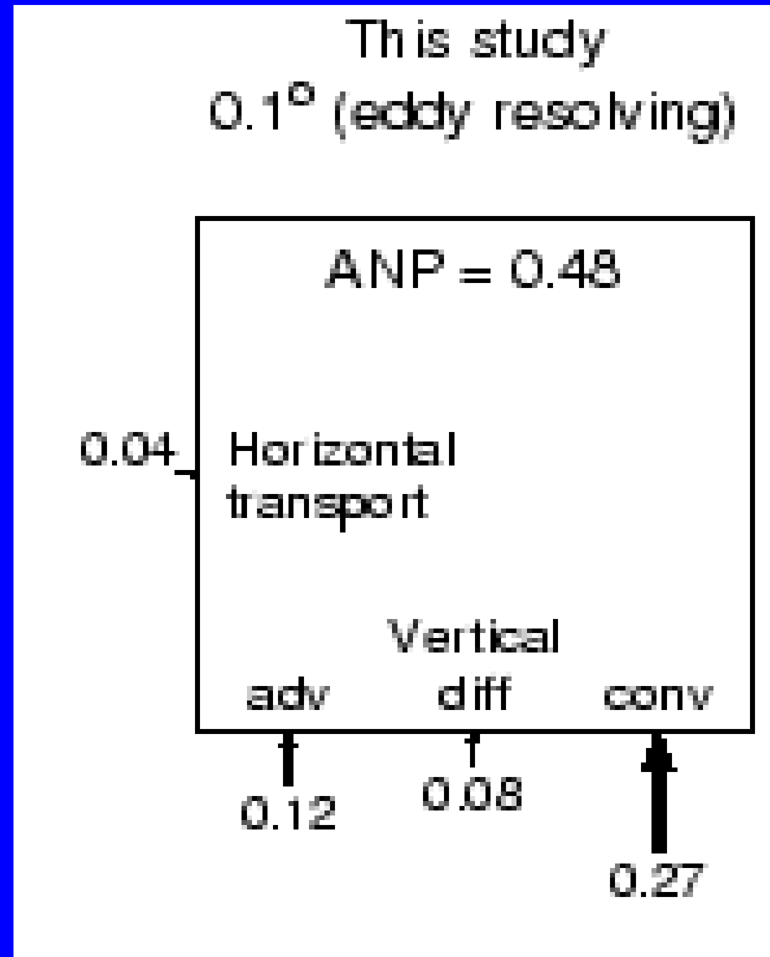
McGillicuddy, Anderson, Doney, Maltrud (2003)

New Production at BATS

“Early JGOFS Era”



“Late JGOFS Era”

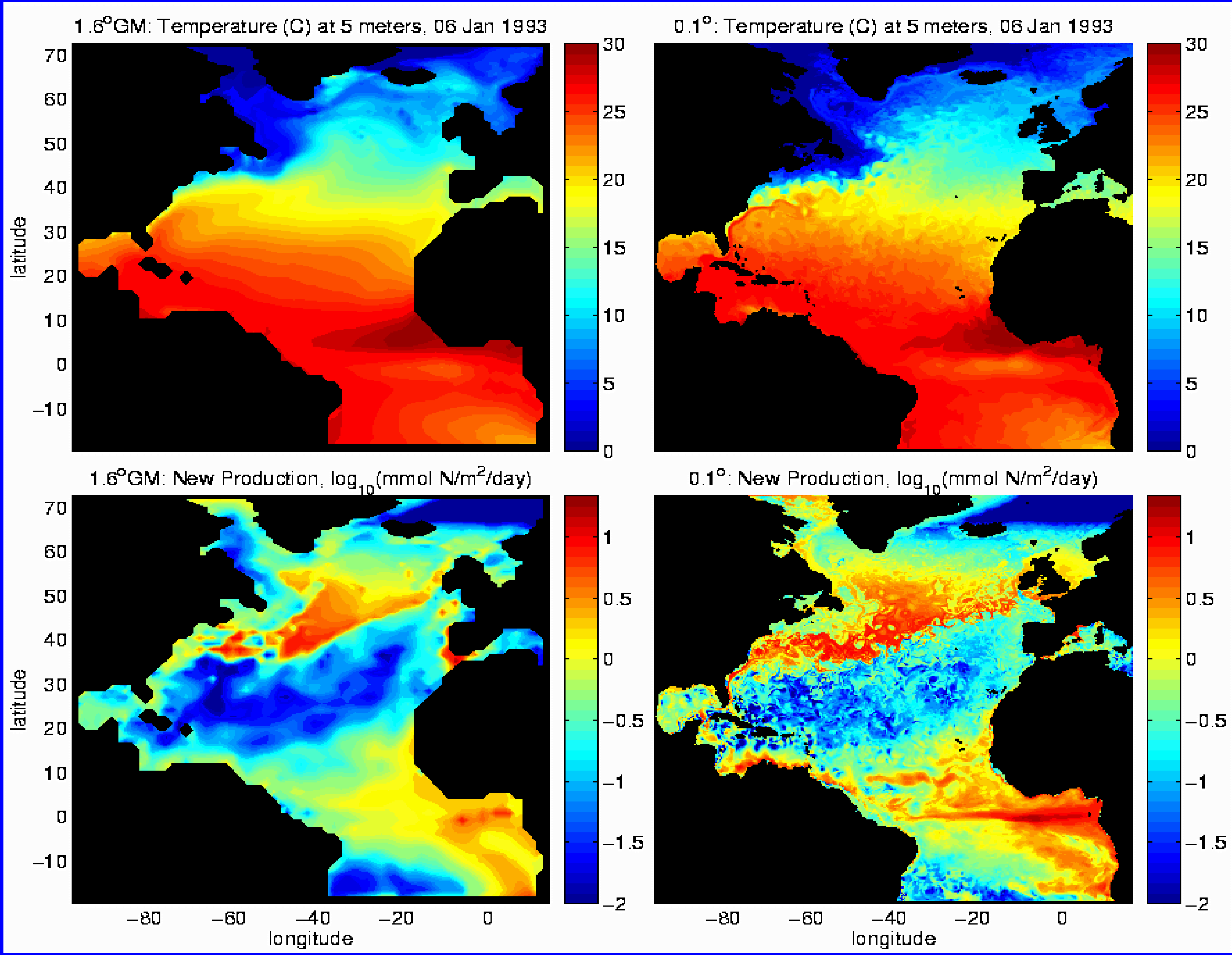


Observed Annual New Production = 0.5 mol N m^{-2} yr^{-1}

Coarse (1.6º) Eddy-resolving (0.1º)

Sea Surface Temperature

log (New Production)



Conclusions

Mesoscale motions create space/time heterogeneity in physical, biological, and chemical constituents in the water column.

Mesoscale processes can drive significant fluxes that affect local, regional, and basin-scale biogeochemical budgets.

A mechanism for modulation of the biological pump:

Phys./chem. disturbance →

Physiological response →

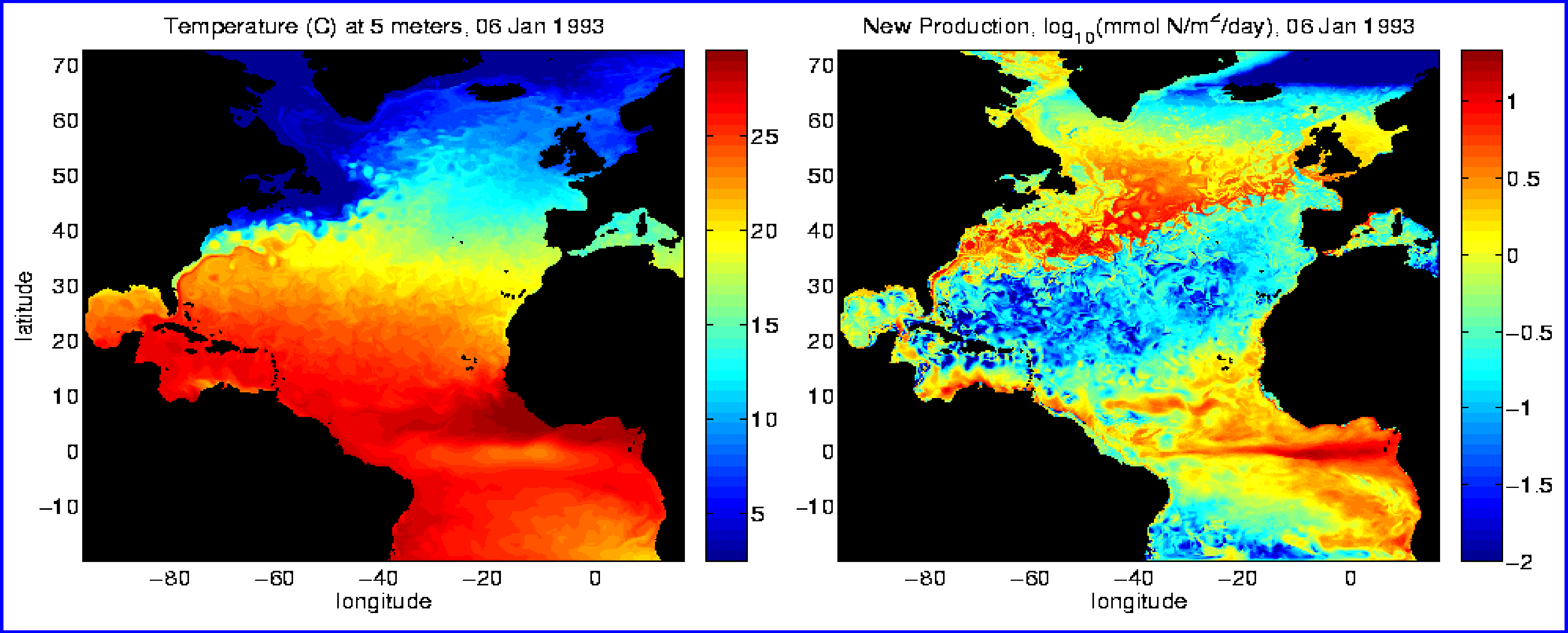
Shifts in species composition →

Changes in export flux

An eddy-resolving model of the North Atlantic

Temperature

log (New Production)



END